Jamming from Granular Materials to Glasses I

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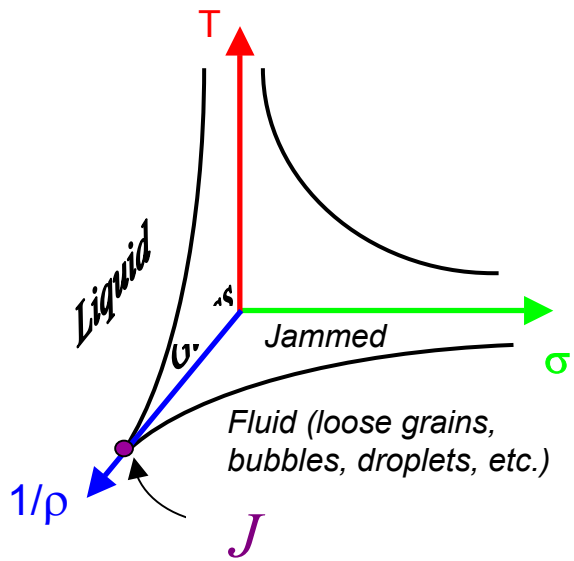
Jamming occurs when particles get stuck. The photograph on the right shows such a jammed state for mustard seeds. Similar jamming occurs in many industrial applications such as flow of granular materials or slurries through hoppers, handling of fine powders, and formation of plastics and foams. It may even be relevant to traffic on highways. Jamming can occur in systems with particle sizes that range all the way from the atomic size through the nanoscale to meters. We have shown how to think of all these systems within a common framework. The essence of our viewpoint is embedded in the jamming phase diagram shown on the right. In this diagram, we show how systems can be jammed by decreasing temperature, T, increasing packing density, ρ, or decreasing shear stress, σ.

We have discovered a special point, labeled J on the diagram. This is the point relevant to the mustard seeds in the photograph at right. Point J has unique properties. In particular, this point behaves in many ways as if it were a critical phase transition (such as that which



Jamming from Granular Materials to Glasses II

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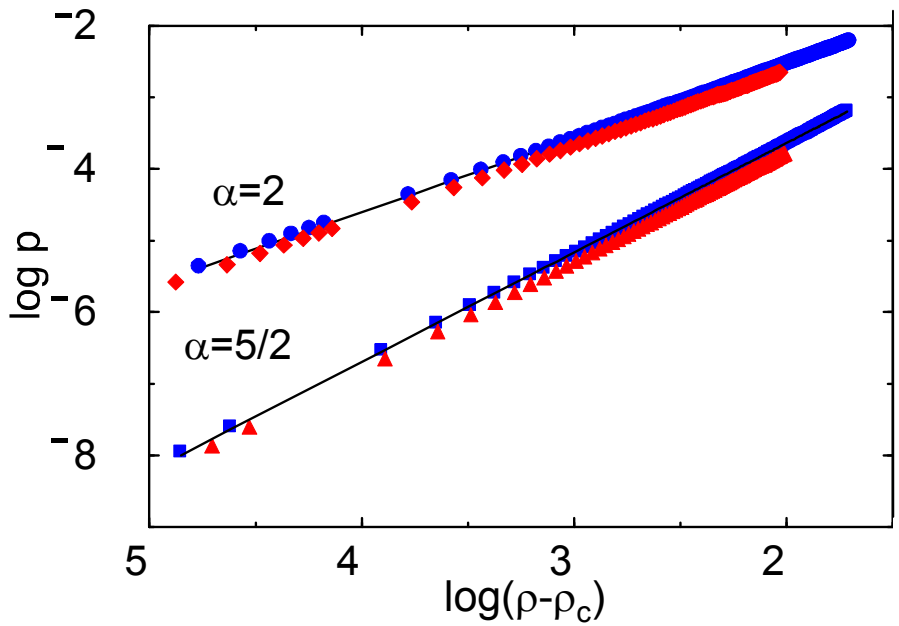
governs magnetism). Thus, we found power-law scaling behavior near this point, as shown in the figure on the right. On the other hand, this point has properties unlike any other critical point ever studied. The properties of point J are related to the mathematics of random close-packing geometries, the engineering of silos, the physical chemistry of colloidal suspensions, and the physics of glass transitions. Understanding this point should lead to a better understanding of jamming in all its manifestations.



Educational:
- 4 undergraduate students
- 4 graduate students
- 2 research associates

Outreach activities:
- Helped many grade school, middle school and high school students with science fair projects in this area of study.
- Co-director of National Science Olympiad
- Taught at Boulder Condensed Matter and Materials Physics Summer School
- Given public lectures and been featured in television and radio programs and articles in the popular press.